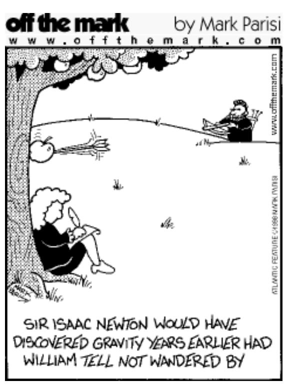
Announcements 25 Mar 09

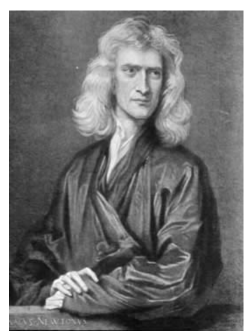
- **Homework #7**
  - **Written homework due at the beginning of class on Friday**
  - **Online homework due on Tuesday next week**
- **Office hours**
  - **Thursday 2:00 to 3:30 pm this week**

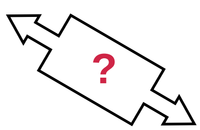
1

The Force of Gravity



Sir Isaac Newton





Is there a connection between these two motions?

Apple falling from a tree vs. Moon orbiting Earth

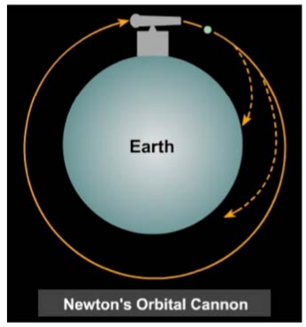
2

Newton's profound insight

Imagine the force pulling on the apple has a range that extends far above the tree

Imagine a large canon on top of a tall mountain

What happens to the projectile if its Initial horizontal speed is very large?



The speed can be large enough for the projectile to reach orbit and continuously fall toward the center of the Earth

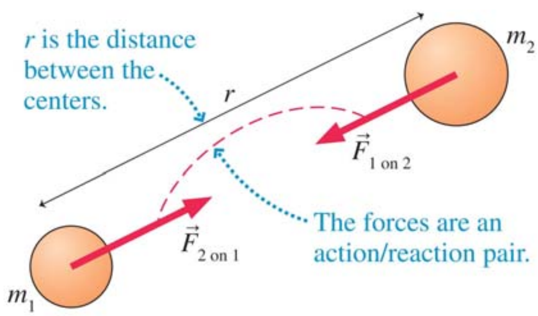
➔ The Moon orbits the Earth by continuously falling toward its center

➔ Connection between "celestial mechanics" and "earthly mechanics"

3

The Force of Gravity

➔"universal" law
i.e. applies everywhere in the Universe



Newton's law of gravity If two objects with masses m_1 and m_2 are a distance r apart, the objects exert attractive forces on each other of magnitude

$$F_{1 \text{ on } 2} = F_{2 \text{ on } 1} = \frac{G m_1 m_2}{r^2} \qquad (6.21)$$

The forces are directed along the line joining the two objects.

The constant G is called the **gravitational constant.** In the SI system of units, G has the value

$$G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$$

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Gravitational force problem 1

A typical bowling ball is spherical, weighs 16 pounds, and has a diameter of 8.5 in. Suppose two bowling balls are right next to each other in the rack. What is the gravitational force between the two—magnitude and direction?

5

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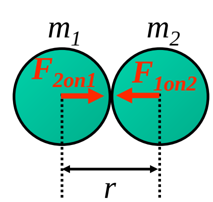

Assume all the mass is concentrated at the center of each ball

Prepare

Know	*Find*
$w_1 = 16 \text{ lb}$	$F_{1on2} = ?$
$w_2 = 16 \text{ lb}$	

$$r = 8.5 \text{ in} = 8.5 \text{ in} \; \frac{0.0254 \text{ m}}{1 \text{ in}} = 0.216 \text{ m}$$

$$w_1 = 16 \text{ lb} \cdot \frac{4.54 \text{ N}}{1 \text{ lb}} = 72.6 \text{ N}$$

Solve

$$m_1 = \frac{w_1}{g} = \frac{72.6 \text{ N}}{9.8 \text{ m/s}^2} = 7.27 \text{ kg}$$

$$F_{1on2} = G\frac{m_1 m_2}{r^2} = \left(6.67 \times 10^{-11} N \cdot m^2/kg^2\right)\frac{(7.27kg)^2}{(0.216m)^2} = 7.55 \times 10^{-8} N$$

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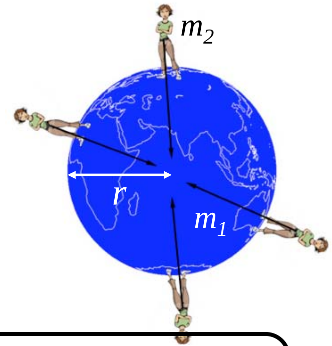
Gravitational force problem 2

What is the magnitude and direction of the force of gravity on a 60 kg person?

Know	*Find*
$m_1 = 5.98 \times 10^{24}$ kg	$F_{1on2} = ?$
$m_2 = 60$ kg	
$r = 6.37 \times 10^6$ m	



Force exerted by the Earth on the person:

$$F_{1on2} = G\frac{m_1 m_2}{r^2} = \left(6.67 \times 10^{-11} N \cdot m^2/kg^2\right)\frac{\left(5.98 \times 10^{24} kg\right)\left(60kg\right)}{\left(6.37 \times 10^6 m\right)^2} = 590N$$

Weight of the person:

$$w = m_2 g = \left(60kg\right)\left(9.8 \text{ m/s}^2\right) = 590\text{N}$$

Gravitational acceleration on the surface of a planet can be generalized as

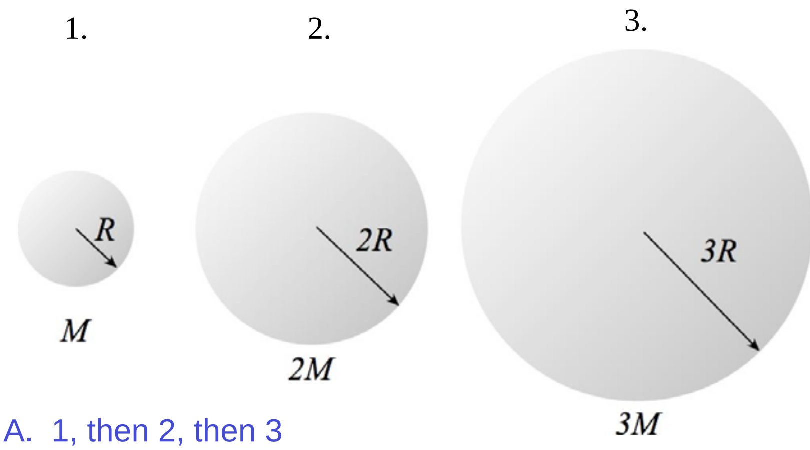
$$g_{planet} = G \cdot \frac{M_{planet}}{\left(R_{planet}\right)^2}$$

7

Gravity on other worlds

PRS

A 60 kg person stands on each of the following planets. Rank order her weight on the three bodies, from highest to lowest.



A. 1, then 2, then 3
B. 3, then 2, then 1
C. All the same

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